Space Weather Technical Forecast

Issued on Saturday, 20 August 2022 at 01:14 Local

This technical forecast provides a four-day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: G1/G2 possible throughout, but risk peaking to start and end four days. R1-R2 and Active electron fluence Likely this UTC weekend.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity was Moderate over the UTC day of Friday 19 August, with X-ray activity at GOES16 showing frequent C-class flares and a peak of M1.6 at 19/0444UTC from AR3078 in the southwest quadrant. This spot was one of up to seven on the solar disc by the period's end, with its immediate western neighbour, AR3083 disappearing from view into the UTC evening.

AR3078 itself showed a marked change over the 24 hours, with its penumbrae on its constituent spots all appearing to shrink, perhaps in part due to its approach to the western solar horizon. Its complexity also changed, with its Dkc/BGD simplifying to Dai/BG over time. This group still proved capable of generating significant activity even as it visually faded, with a C6.7 flare at 19/2031UTC also producing a Type-II radio burst with an associated ejecta speed of 999km/s, with dimming also evident on AIA 211 imagery. Any Earth-bound component arising from this event has yet to be determined, however a mainly south and westward-directed emission seems most likely.

The other six sunspots populating the Earth-facing disc were less complex, with many simple dipoles or else monopoles, with the 'best of the rest' perhaps the nominally more complex AR3081, which finished the 24 hours as a Cki/Beta, with little in the way of flare activity.

A filament visible in the northwestern quadrant near 10 West on H-Alpha imagery gradually disappeared from view through the UTC afternoon of Friday 19 August, however this has yet to manifest on coronagraph imagery, and it may have failed to leave the immediate solar environment. More definite departures in the period were clustered around the southwest quadrant and further flare activity from AR3078, with up to four events seen leaving this part of the solar disc in Lasco C2 in the 24 hours.

The chances of these above events surviving as well-separated CME arrivals to 1AU are considered relatively low, with probable amalgamation and cannibalistic behaviour likely as later CMEs emanating from the prolific AR3078 find the interplanetary medium swept out ahead of them to ease their transit. MOSWOC Enlil modelling suggests that a glancing CME arrival is possible within the UTC day of Tuesday 23 August, probably concurrent with the CIR leading CH16/-. MOSWOC Enlil's ensemble is currently a chaotic mix, with at least some members perturbing the ambient wind to a degree all the way through until early on 24 August, giving particularly low confidence in the geomagnetic forecast detail, and at least a background Slight Chance of G1 on all days of the forecast.

Solar Wind / Geomagnetic Activity: The solar wind speed, as measured by DSCOVR and ACE at L1, was symptomatic of both a fast wind regime from CH14/-, but also a CME arrival at

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19/1702UTC. A 42.0nT deflection in the H-component of Hartland magnetometer was subsequently observed around 19/1735UTC, for which a Sudden Impulse Alert was issued.

The solar wind speed rose from Elevated to Strong with the advent of the CME, having been declining from the upper-500s of km/s past 550km/s before a resurgence after 17UTC to reach the upper-600km/s by the period's end. The associated solar wind density rose slightly over the same period from upper single figures ppcc to low double figures at DSCOVR. The IMF fell from 8nT to 5 in the fast wind before a sharp increase to 12nT into the UTC evening, with the north-south component volatile but with a peak range of +9 and -11nT observed. The phi angle was mainly towards the sun (negative), even after the CME arrival.

The net result of the above solar wind measures was for provisionally Quiet to Unsettled activity in the fast wind, rising to a peak of Kp '5-' G1 Minor Storm in the 18-21UTC interval with the CME.

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10 MeV), as measured by GOES16, was very slightly above its typical Background level, but still comfortably below S1. The cause of this enhancement is likely to have been flare activity from AR3078, although discerning which is not likely to be possible given the cadence of similar magnitude flares and CMEs from this region.

The high energy electron flux (greater than 2 MeV) showed a rising trend over the 24 hours: from Normal Background to peak at High, with GOES16 recording 2100pfu at 19/1735UTC. The 24-hour integrated electron fluence was below the Active threshold, but with a rising trend also evident and with an observed value of 5.2e7 integrated pfu at 20/0000UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity is Likely to be Moderate over the UTC weekend, with further M-class flares Likely, primarily from AR3078 in the southwest quadrant. This region should rotate off the disc into the new working week, with the chances of further such flares falling in tandem. No significant regions are expected over the eastern limb in the period to slow this fall.

Solar Wind / Geomagnetic Activity: The geomagnetic forecast is low confidence throughout, largely the result of the sheer number of mostly minor CME emissions from AR3078, with amalgamation of these likely and some cases of glancing incidence possible. These events have been frequent enough that MOSWOC Enlil's ensemble is now a turbulent mix throughout the four days and on until early on 24 August, with at least some members offering a Slight Chance of G1 on all days of the forecast, peaking on day one with a Likely G1/G2 (Saturday 20 August) and again on day four, with a Chance of G1/G2 (Tuesday 23 August). These peaks are due to more definite CME arrivals coinciding with peak fast wind activity from CH14 and CH16 respectively.

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10 MeV) will most likely remain at Background levels, although there is a slight chance of an S1 or greater event, mainly due to AR3078.

High energy electron flux should show an upward tendency in the period, the result of reaction to the fast wind from coronal hole 14, albeit tempered by any CME arrivals, which should serve to lower confidence in the forecast. On balance, Active fluence is perhaps Likely over the UTC weekend and at first in the working week, falling to a Chance by day four, Tuesday 23 August as a result of twin arrivals from a CIR from CH16/- and a CME.

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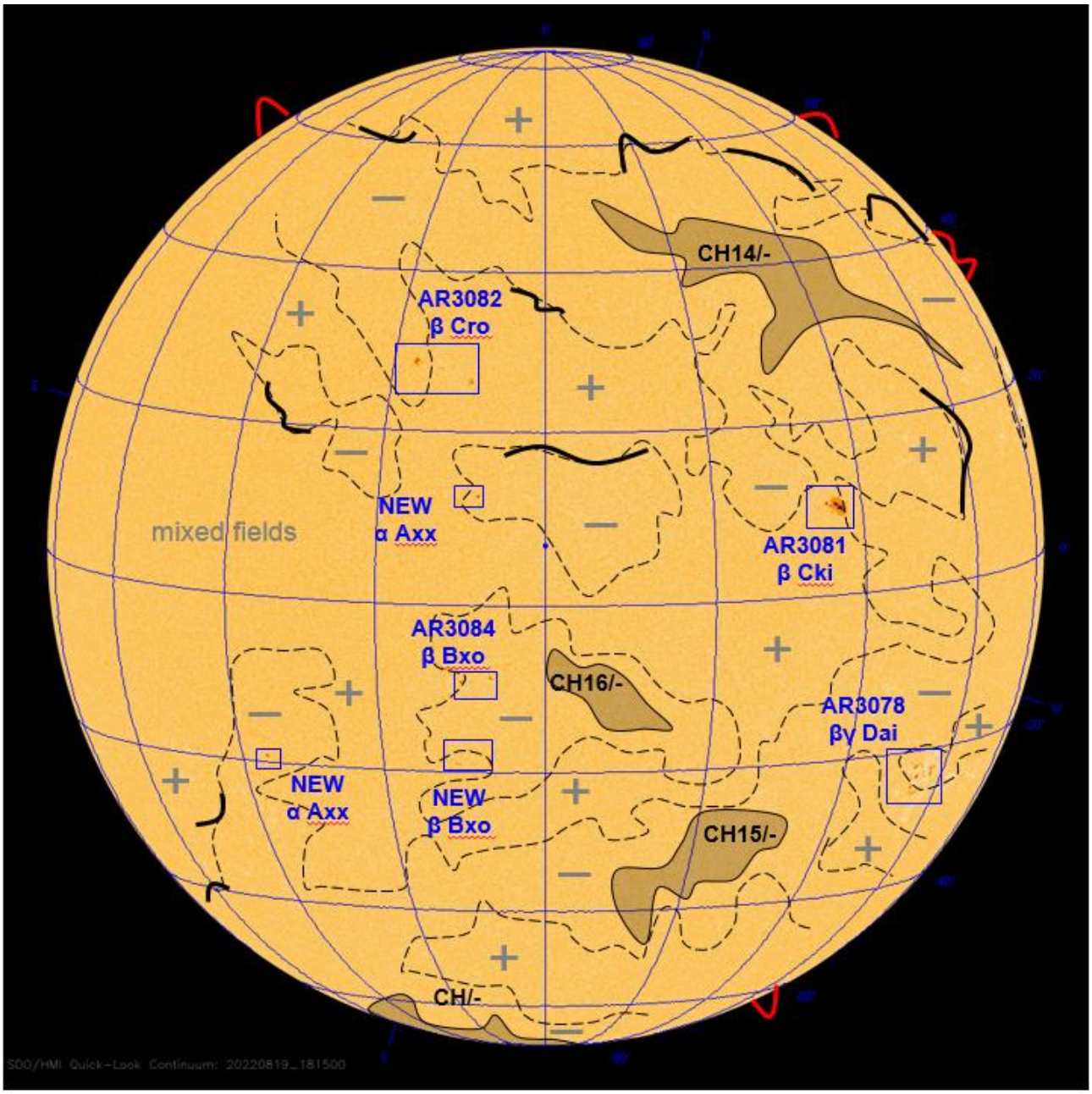
Figure 1. Solar Analysis Valid 19/1815UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

The geomagnetic forecast is low confidence throughout, largely the result of the sheer number of mostly minor CME emissions from AR3078, with amalgamation of these likely and some cases of glancing incidence possible.

These events have been frequent enough that MOSWOC Enlil's ensemble is now a turbulent mix throughout the four days and on until early on 24 August, with at least some members offering a Slight Chance of G1 on all days of the forecast, peaking on day one with a Likely G1/G2 (Saturday 20 August) and again on day four, with a Chance of G1/G2 (Tuesday 23 August).

These peaks are due to more definite CME arrivals coinciding with peak fast wind activity from CH14 and CH16 respectively.

STEREO A's solar wind is now comfortably in decline, implying that the fast wind from CH14 may not see out the weekend. CH16 is not a persistent feature on the disc, however it has yet to manifest at STEREO A, implying it is at least 2 days away from affecting Earth. MOSWOC Enlil has recently been verifying well against coronal hole features, and there is no reason to doubt its forecast arrival of CH16 within the UTC day of 23 August other than perhaps interaction with a coincident CME, which is by nature lower confidence.

The geomagnetic outlook beyond the current UTC weekend and first half of the working week should be a quietening trend, with the eastern solar hemisphere devoid of significant features, and with AR3078 expected to depart the Earth-facing side with the advent of the new week.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	Yes	50	10	10	40
Strong	G3	No	5	1	1	5
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

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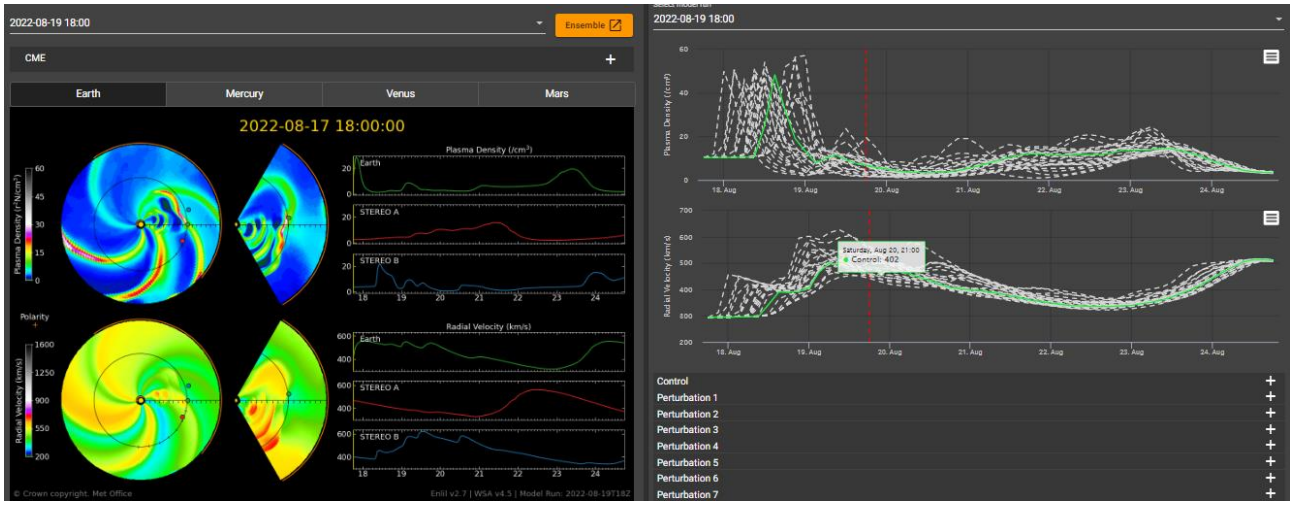
Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
16/0740	Partial	AR3078	South Centre	600km/s	19/0001 +/- 12hours	Glancing Blow, perhaps amalgamated with following CME and arrived 19/1702UTC
17/1430	Partial	AR3078	Southwest	970km/s	19/2100 +/- 12 hours	Glancing Blow, perhaps arrived 19/1702UTC
19/0939	Partial	AR3078	Southwest	458km/s	23/1200 +/- 12 hours	Glance, probably coincident with CIR from CH16/-

Figure 2: Latest MOSWOC Enlil run (left), showing a series of closely-spaced CME emissions from AR3078. Also shown is the ensemble (right) showing a protracted period of pertubed solutions through the coming four days.



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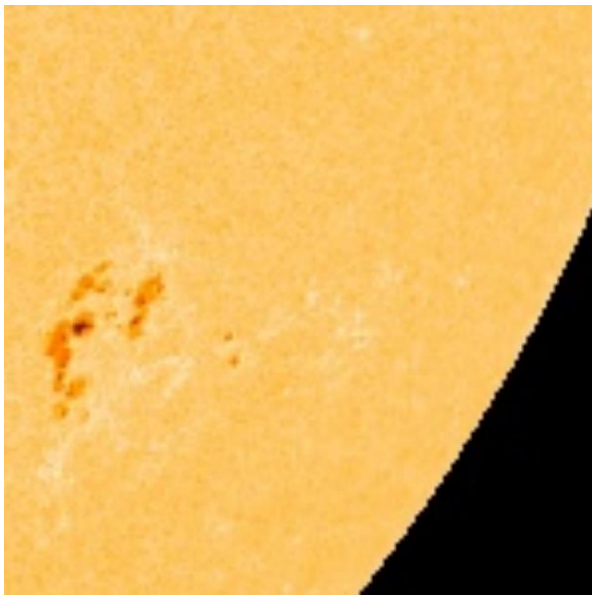
Radio Blackouts - X-Ray Flares:

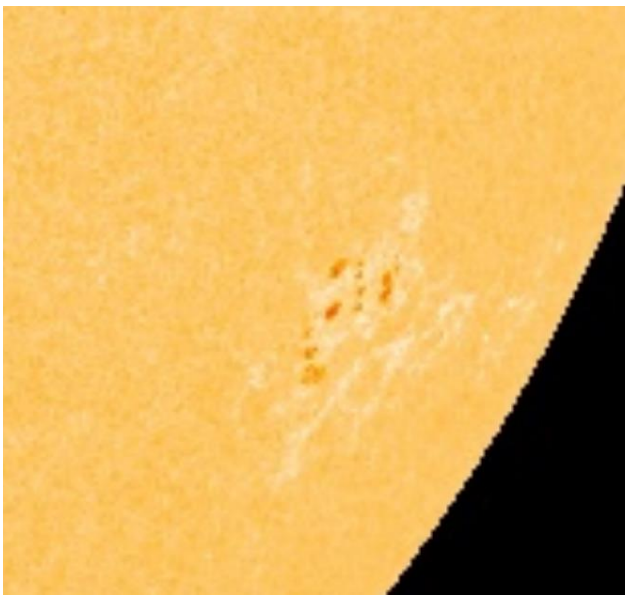
Despite there being up to seven sunspot regions on the facing side of the sun at present, solar activity is currently dominated by AR3078 near the southwestern limb. This group has produced numerous M and C-class flares as well as CMEs in the past few days, and similar is expected over the coming weekend. An apparent simplifying trend in recent hours may be in part down to the narrowing viewing angle, although there does appear to be a genuine shrinking of some of the constituent spots' penumbrae - becoming a Dai/BG from a peak of Dkc/BGD.

M-class flares remain Likely over the UTC weekend, but fall into the new working week as AR3078 departs, with much of the remainder of the Earth-facing disc offering little of interest - barring significant development. The arriving eastern limb is also not expected to provide much in the way of additional risk later in the period, with the result that the daily Likely M-class should fall to a Chance from Monday 22 August.

X Ray Flares Probability	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	R1-R2 M Class	Yes	60	50	25	25
Very Active	R3 to R5 X Class	No	5	5	1	1

Figure 3: HMIIF imagery of sunspot region AR3078 at 18/2220UTC and 19/2220UTC, showing a decaying tendency as well as limb foreshortening effects. In particular there appears to have been penumbral decay such that there is no longer a Mt Wilson delta spot evident in its trailing portion.





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Solar Radiation Storms - (High Energy Protons):

The high energy proton flux (greater than 10 MeV) is currently very slightly above its typical Background range, having been so since the second half of the UTC day of Thursday 18 August. Potentially causative X-ray flare events from AR3078 have been frequent enough that tying this initial enhancement to any one event is problematic, but it perhaps best fits the M1.5 at 18/1054UTC.

This sunspot region is now nearing the better-connecting western solar horizon, and although it has yet to generate an S1 it carries a Slight Chance of doing so, even as it transits onto the far side through Monday 22 August. Contributions from other spots on the disc are relatively slight.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	≥ S1	No	10	10	10	10
Very Active	≥ S3 *	No	1	1	1	1

* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)

Figure 4: Past week in GOES16 high energy protons (top) and GOES16 X-ray flux (bottom). Slight enhancements have occurred to separate the greater than 10MeV trace at times through the past week from its more energetic neighbours.

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High Energy Electrons Event (≥ 2MeV):

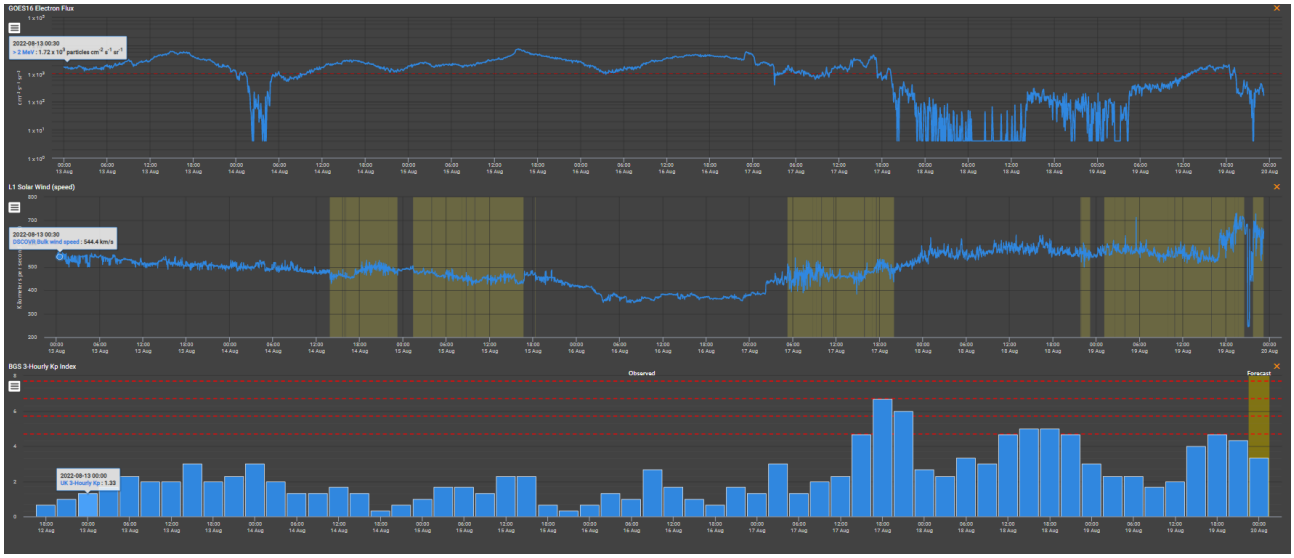
High energy electron flux has shown a response to both the current fast wind from CH14, but also the successive CMEs, with effects combining to make the electron forecast both volatile and of relatively low confidence.

Allowed to develop fully, the current 650km/s fast wind would very likely prove capable of generating 24-hour integrated Active electron fluence, and may still do so, however this will play off against at least Minor Geomagnetic Storm G1 conditions from arriving CMEs, at least into the current UTC weekend and perhaps again with the twin arrivals of a further CME and a CIR leading CH16/- on Tuesday 23 August. This final event is perhaps the most likely to occur - for being partly reliant on a more definite fast wind arrival. This is likely to drop flux levels on onset, however a Chance of Active fluence survives to day four as a result of levels leading into the UTC day, i.e. prior to any CIR or CME.

As stated, there is high uncertainty in the forecast, however levels reached by the end of the current UTC weekend should perhaps then be maintained until Tuesday's CME and CIR. Active fluence is near-evens in terms of risk, but perhaps slightly more likely than not to occur before the more definite decline before midweek.

GEO Electron Environment	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ $1x10^8$	No	60	60	50	40
Very Active	≥ 2 MeV ≥ $1x10^9$	No	1	10	5	1

Figure 5: Past week in GOES16 electron flux (top); L1 solar wind speed (middle) and BGS 3-hourly Kp index (bottom). The interplay between the lower two plots and their effect on electron can be seen. The current fast wind and CME-affected regime is Likely to result in Active fluence, as suggested by the latest MOSWOC REFM overleaf.



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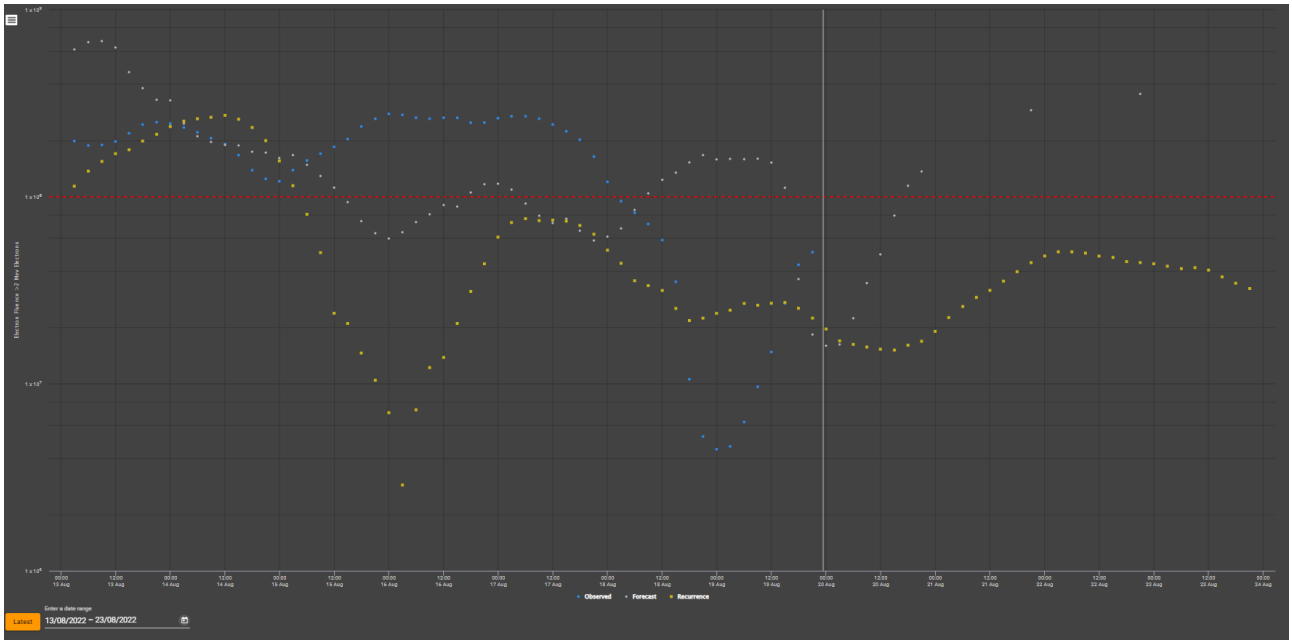

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